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REPUBLIC OF SOUTH AFRICA
PATENTS ACT, 1978

AND ACKNOWLEDGEMENT OF RECEIPT
(Section 30(1) — Regulation 22)

The grant of a patent is hereby requested by the undermentioned applicant on the basis of the present application filed in duplicate.

Revenue Stamps or Revenue Franking Machine Impression

OFFICIAL DATE STAMP

OFFICIAL APPLICATION NO.

21	01	941443

FULL NAME(S) OF APPLICANT(S)

71	EXPERT EXPLOSIVES (PROPRIETARY) LIMITED

ADDRESS(ES) OF APPLICANT(S)

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MODDERFONTEIN,
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TITLE OF INVENTION

54	BLASTING SYSTEM

PRIORITY IS CLAIMED AS SET OUT ON THE ACCOMPANYING FORM P.2.

The earliest priority date claimed is:
(ZA) South African Patent Application No.93/1702 filed 10 March 1993

~~THIS APPLICATION IS FOR A PATENT OF ADDITION TO PATENT APPLICATION NO.~~

21	01	

~~THIS APPLICATION IS ACCOMPANIED BY:~~

XX	1 A single copy of a provisional or two copies of a complete specification of 22 pages
XX	2 Drawings of 5 sheets. (Formal/informal).
XX	3 Publication particulars and abstract (Form P.8. in duplicate)
XX	4 A copy of Figure 3 of the drawings (if any) for the abstract.
XX	5 Assignment of invention.
	6 Certified priority document(s) — State number.
	7 Translation of the priority document(s).
	8 An assignment of priority rights.
XX	9 A copy of the Form P.2. and the specification of S.A. Patent Application No.
XX	10 A declaration and power of attorney on Form P.3.
	11 Request for ante-dating on Form P.4.
	12 Request for classification on Form P.9.
XX	13 Form P.2. in duplicate.

21	01	93/1702

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Dated this 2nd day of MARCH 1994

McCALLUM, RADEMEYER & FREIMOND
APPLICANT'S PATENT AGENTS

REGISTRAR OF PATENTS

FORM P7

REPUBLIC OF SOUTH AFRICA
PATENTS ACT, 1978

COMPLETE SPECIFICATION

(Section 30(1) — Regulation 28)

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21	01	94 1443

INTERNATIONAL CLASSIFICATION		LODGING DATE	
51	F42B; F42C; F42D.	22	2.3.1994

FULL NAME(S) OF APPLICANT(S)

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FULL NAME(S) OF INVENTOR (S)

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TITLE OF INVENTION

54	BLASTING SYSTEM

Grif Bros. WT 1191

BACKGROUND OF THE INVENTION

This invention relates to an electronic blasting system.

Blasting systems which are suitable for use in a mining environment and which are known to the applicant fall broadly into two categories.

In the first instance sequencing systems are known wherein blasts are sequenced, from detonator to detonator, in succession along a connecting cable or wire. Systems of this type are described for example in the following patent specifications: ZA 72/8188, ZA 72/8368, ZA 90/0685, ZA 92/3159, GB 2020119A and DE 3835627. It is inherent in this category of systems that their application is limited to delay sequences which progress from one end of the connecting cable or wire to the other end.

The second category of blasting systems is more flexible in that complex blasts with arbitrary delay patterns can be implemented. These features are achieved by utilising, in each detonator, a programmable electronic device which enables an ideal delay pattern to be designed on a computer, and then programming each detonator with an appropriate delay.

In order for a detonator to be programmed with a selected time delay it is necessary to be able to communicate with that detonator uniquely. This implies that each detonator must be uniquely identifiable. Any of the following methods may be used for programming a time delay to a detonator.

1. Each detonator is assigned a unique address during its manufacture, under factory conditions. Thereafter a blast control computer is used to communicate, via a common trunk line, with each detonator which is selected utilising its unique address. A disadvantage of this system is that a variety of numbered detonators must be made, see for example U.S.A. 4986183.

2. Each detonator may be numbered in the field using an address programmer. A unique address is assigned to each detonator prior to its connection in a blasting system. Thereafter a blast control computer can individually address each detonator on a common parallel or serial bus. See for example EU88308945.2.

3. An interconnection system is adopted in which at least one wire goes from an output of one detonator to an input of a following detonator so that the detonators may be sequentially addressed along a wiring harness. With this type of daisy chain system a control computer sends

a message to the first detonator and, once the message has been processed, the first detonator either relays the next message to the following detonator or enables the following detonator to process the next message. See for example ZA 91/7550, ZA 90/7794 and GB 2190730A.

4. A delay period may be directly assigned to each detonator, using a field programmer, prior to its connection to a blasting system. With this approach the time delay is loaded directly into each detonator and the system is not re-programmable once fully connected. See ZA 89/5838.

5. In ZA 79/0355 use is made of factory preset multiplier numbers in which the number indicates the number of delay periods to be used. This is a prenumbered system and for example a detonator with the number N, where N may be any integer, has a delay period which is equal to N times a reference delay period, before firing. The reference delay period is generated by a shot exploder.

SUMMARY OF THE INVENTION

The invention is concerned with a blasting system which requires minimal wire implementation while maintaining programmability. All detonators which are included in this system may be identical and can be employed

for any blast. The system also allows connection or electronic faults to be detected immediately, a feature which is highly beneficial in situations where many detonators are connected to a trunk line for a large blast.

The invention provides, in the first instance, apparatus for use with a detonator which includes means for generating and transmitting to the detonator at least one test signal, means for receiving at least one signal which is transmitted by the detonator in response to the test signal and which relates to a status of the detonator, means for providing an indication of the status, and means for generating and transmitting to the detonator an address which uniquely identifies the detonator.

The means for providing an indication of the status of the detonator may be a visual display or produce an audible signal. Both visual and audible signals may be generated if required.

The indication of the status may be provided at the apparatus or at a remote point. For example the status indication may be transmitted by means of a radio or other link to any remote point, for example to a location which is near the detonator.

The indication of the status may take on any suitable form and in a preferred embodiment of the invention a signal is generated which

indicates the address of the detonator. Thus the address which uniquely identifies the detonator may be audibly announced or displayed on a visual display device to indicate that the status is satisfactory.

The status of the detonator may relate to any aspect which is associated internally or externally with the detonator including its connection to a reticulation or blasting system.

The invention also extends to a method of installing a detonator in a detonating system which includes the steps of connecting the detonator in the system, generating and transmitting to the detonator at least one test signal, transmitting from the detonator a signal in response to the test signal which relates to a status of the detonator, providing an indication of the status of the detonator, and generating and transmitting to the detonator an address which uniquely identifies the detonator.

The test signal is preferably generated at a control location which is remote from the detonator position. The test signal may be of any appropriate composition which is incapable of arming or firing a detonator. Thus for example the energy carried by the signal may be limited or the signal may be encoded or encrypted to render it incapable of arming or firing the detonator.

The status of the detonator may be any factor which is associated internally or externally with the detonator. Thus for example the status may relate to the operability of any circuit or component of the detonator, or to the integrity of an electrical connection inside the detonator or to the integrity of a connection between the detonator and any other component e.g. a connecting wire or cable, in a blasting system.

The status may be indicated visually or audibly. In a preferred embodiment of the invention the status is indicated by means of a visual display and, in addition, a status signal is audibly generated at a location at or near the detonator. The status signal may for example be transmitted by means of a radio link to a location near the detonator.

The address which uniquely identifies the detonator may be assigned to the detonator only if the status of the detonator, in all respects, is acceptable. Thus the assignation of an address to a detonator may, in itself, indicate that the status of the detonator is acceptable.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is further described by way of example with reference to the accompanying drawings in which:

Figure 1 schematically depicts a blasting system in accordance with the invention,

Figure 2 is a block diagram of testing apparatus used in the system shown in Figure 1,

Figure 3 is a block diagram representation of a detonator which is used in the blasting system,

Figure 4 shows three testers, of the type illustrated in Figure 2, under the control of a computer, and

Figure 5 is a schematic representation of detonators installed near a rock face which is to be blasted.

DESCRIPTION OF PREFERRED EMBODIMENT

Figure 1 of the accompanying drawings illustrates testing apparatus 10 which is shown in greater detail, but in block diagram form, in Figure 2, a plurality of programmable detonators 12 to 22 respectively, a visual display 24, a loudspeaker 26, and a radio receiver 28 which is connected to ear phones 30 adapted to be worn by an operator 32.

Referring to Figure 2 the testing apparatus 10 includes the following modules: a central processor 34, random access memory 36, read only memory 38 which is used for program storage, an interface port 40 for connecting the tester 10 to a computer 42, as is shown in Figure 4, a trunk line driver 44, a speech synthesizer 46 which is connected to a loud speaker 48, a numeric display 50, a programmable power supply 52, a battery 54 which is used for testing, a transmitter 56 which works at radio frequency or at an infra-red frequency, according to requirement, and an address selector 58.

The speech synthesizer 46, the numeric display 50 and the transmitter 56 are used to feed information to the operator 32. The battery 54 is adequate to test individual detonators but is incapable of programming, arming or firing the detonators.

The trunk line driver 44 is connected to the battery 54 and externally to the blast control computer 42 of Figure 4.

Figure 4 illustrates three of the testers designated 10A, 10B and 10C respectively connected to respective trunk lines 60A, 60B and 60C. The computer 42 is capable of providing adequate energy for charging capacitors in the respective detonators and for arming and firing the detonators. The computer also provides coded signals for programming and initiating each detonator.

Use is made of a custom designed card 62 which is installed in the computer 42 for communication with the individual testers 10A, 10B and 10C. The power to initiate the detonators is sent from this card.

Figure 3 is a block diagram representation of a typical detonator used in the blasting system of the invention. The detonator includes a protection block 64, a detection module 66, a message processor 68, a main chip controller 70, a memory device 72, an oscillator 74, a second memory device 76, a control module 78, a storage and firing capacitor 80 and a delay counter 82.

The block 64 contains over-voltage and over-current protection against static discharge or stray induced currents. The detection module 66 resets

the main chip controller 70 at power up. The message processor 68 interprets messages to the controller 70 and responds to the tester 10. The controller 70 acts on the messages and sets the address memory module 76 when instructed to do so. After the correct sequence of messages the chip controller causes the storage capacitor 80 to be charged and it then initiates the programmed timed delay before firing the explosives initiator. The oscillator 74 provides timing pulses for communication and delay generation.

The detonator has been shown in block diagram form only for its construction and operation are known to those skilled in the art.

Each of the detonators 12 to 22 of Figure 1 is of the type shown in Figure 3. Each detonator includes two leg wires 84 which are connected by a two wire trunk line 60 to the tester 10. In use each of the detonators is connected in parallel to the trunk line 60.

It is inherent in the blasting system of the invention that the individual detonators can be connected in any desired sequence to the trunk line. Thus, referring to Figure 1, the detonators are connected to the trunk line in the following sequence: the detonator 12 is first connected to the trunk line and is followed by the detonator 16, the detonator 14, the detonator 20 and the detonator 22. The detonator 18, as shown, is not connected to

the trunk line. As each detonator is connected to the trunk line the apparatus 10 detects the connection. A unique address number is generated and this, together with at least one intrinsically safe test signal, is transmitted by the apparatus on the trunk line 60 to the respective detonator. The signal is received by the detonator and one or more validation or diagnostic checks are carried out on the detonator. If everything is in order the unique address is stored in the detonator and a signal is generated by the detonator and transmitted on the trunk line 60, back to the apparatus 10, to confirm the status of the detonator. 'Status', as used herein, is intended to include any aspect of a detonator which relates to its working, including the functioning of circuits in the detonator, the integrity of the interconnection of the circuits, and the integrity of the connection of the detonator to the trunk line.

When the apparatus 10 receives the confirming signal from the detonator in question, action is taken to advise the operator 32 that everything is in order. Thus for example the address which has been assigned to the detonator in question can be displayed or announced. In the example shown in Figure 1, the detonator 22 has been assigned the address No.5. The address number is displayed on the visual display 24 which is of a size and so positioned as to be easily visually identified by the operator 32, or audibly announced on the loudspeaker 26. Alternatively or additionally a status signal is sent to the receiver 28 which carries an

onboard display which displays the address number 5. The receiver 28, in this example, includes a voice synthesizer and the number 5 is generated and is audibly repeated on the ear phones 30 which are worn by the operator.

The feedback of the address which has been assigned to the detonator in question, using any of the aforementioned techniques, confirms that the detonator has been correctly connected to the trunk line 60. If the operator does not receive a feedback signal or if an error signal is received, then the operator is thereby notified that the detonator 22 or the connection of the detonator 22 to the trunk line, is faulty. Steps can immediately be taken on the spot to rectify the fault.

It is to be borne in mind that the detonators are identical and that, through the use of the system, all that is required is to connect the detonators one after the other in parallel to the two wire trunk line. It is also possible to connect a detonator to the legs of a pre-connected detonator to simplify wiring complexity.

It follows that using the techniques of the invention each detonator is given an address number which uniquely identifies the detonator and which corresponds to the chronological order in which the detonators are connected to the trunk line. Thus the first detonator which is connected

C 24

to the trunk line is unit 1 and the Nth unit which is connected to the trunk line is unit N. This permits the operator to connect the units to the trunk line in an order which is appropriate for the particular conditions. If the address number which is assigned to a detonator is to be visible then a small prenumbered sticker can be attached to each detonator by the operator 32 when prompted by a signal, sent for the purpose, by the apparatus 10.

Figure 5 schematically depicts 15 detonator units which have what are referred to as chronological addresses and which are arranged in three banks 86A, 86B and 86C respectively, each having 5 units. The detonator units in the first bank 86A require zero delay, the units in the bank 86B require 10 ms delays while the units in the bank 86C require 17 ms delay periods.

The detonator units are connected to a trunk line 60. The numbers on the trunk line, near each respective detonator, denote the positional address of each detonator which, as has been explained in connection with Figure 1, is the same as its position in the connection sequence.

The following table sets out the address which is assigned, using the techniques described hereinbefore with reference to Figure 1, to each detonator, its desired delay period, and its chronological address. The

chronological addresses correspond with the delays of the respective detonators in the sense that the lower addresses from 1 to 5 have zero delay periods, the next bank of chronological addresses from 6 to 10 have delay periods of 10 ms, and the chronological addresses in the final bank have delays periods of 17 ms.

TABLE

Address = Position in Sequence	Delay (ms)	Chronological Address
1	17	11
2	17	12
3	10	9
4	17	13
5	17	14
6	10	6
7	17	15
8	0	5
9	0	4
10	10	7
11	10	8
12	0	3
13	0	2
14	0	1
15	10	10

The physical ordering of the detonators along the trunk line is not important. This is because each detonator is given a unique address which, once correlated with the actual physical position of the detonator at the blasting location, enables substantially any desired blasting sequence to be programmed into the system.

In one embodiment of the invention use is made of two discreet pieces of equipment to complete the blasting process. Thus in the first instance use is made of the testing apparatus 10 to test and program the identity of each new detonator as it is connected to the trunk line, in the manner which has been described hereinbefore. A second item of equipment is thereafter used to program the individual time delay periods for the respective detonators and then to arm and fire the detonators.

The testing apparatus 10 is constructed so that it cannot arm nor fire any detonator. This may be achieved in any appropriate way for example by limiting the energy which is available from the apparatus, and by using encoded messages and electronic interlock circuits on each detonator. This type of technology is described for example in GB 2190730A.

The second piece of equipment which is referred to generally as a firing box can provide adequate energy to charge an energy storage device in each respective detonator, and to arm and fire the detonators. The firing box is also used when appropriate to provide coded signals to cause each detonator to be initiated.

With a modified technique the detonators are connected to the trunk line in the manner which has been described and once the status of each detonator has been confirmed a firing box is connected to the apparatus

10 to provide the ability to initiate a blast. A safety interlock is used to prevent the apparatus 10 from initiating a blast until such time as the firing box is connected.

The construction of each of the detonators has been described only in block diagram form for they may be of any appropriate type capable of interacting with the apparatus 10 in the manner which has been described.

Bi-directional communications on the trunk line are preferably effected by means of coded signals carrying digital information to and from the detonators. Communication to the detonators could for example be by means of voltage modulated signals superimposed on a DC level while communication from the detonators could be by means of current pulses drawn from a DC level on the trunk line.

CLAIMS

1. A method of installing a blasting system which includes a plurality of detonators, the method including the steps of monitoring the system to detect the connection of a fresh detonator to the system and, when this is detected, of assigning a unique address to the fresh detonator.

2. A method according to claim 1 wherein the system is monitored by repeatedly transmitting from a control location a test signal to all the detonators in the system, configuring the detonators to which respective unique addresses have already been assigned so that they are not responsive to the test signal, and configuring the fresh detonator so that it transmits, to the control location, a second signal in response to the test signal.

3. A method of installing a fresh detonator in a detonating system which includes a plurality of already installed detonators, the method including the steps of connecting the fresh detonator in the system, generating and transmitting to all of the detonators at least one test signal, transmitting only from the fresh detonator a signal in response to the test signal which relates to a status of the fresh detonator,

providing an indication of the status of the fresh detonator, and generating and transmitting to the fresh detonator an address which uniquely identifies the fresh detonator.

4. A method according to claim 3 wherein the test signal is generated at a control location which is remote from the fresh detonator.

5. A method according to claim 3 or 4 wherein the test signal is incapable of arming or firing any of the detonators.

6. A method according to claim 5 wherein the test signal complies with at least one of the following to render the signal incapable of arming or firing the detonator: the energy carried by the test signal is limited; the test signal is encoded or encrypted.

7. A method according to any one of claims 3 to 6 wherein the status of the fresh detonator relates to at least one of the following: the operability of any circuit or component of the fresh detonator; the integrity of an electrical connection inside the fresh detonator; the integrity of a connection between the fresh detonator and any other component in the detonating system.

8. A method according to any one of claims 3 to 7 wherein the status of the fresh detonator is indicated by at least one of the following: a visual display; an audible signal.

9. A method according to any one of claims 3 to 8 wherein the status signal is transmitted by means of a radio link to a location near the fresh detonator.

10. A method according to any one of claims 3 to 9 which includes the step of generating and transmitting to the fresh detonator the said address which uniquely identifies the fresh detonator, only if the status of the fresh detonator is acceptable.

11. A blasting system which includes a trunk line, a plurality of programmable detonators individually connected to the trunk line, and control means for detecting a connection of a fresh detonator to the trunk line and for generating a unique address which is transmitted on the trunk line to the fresh detonator.

12. A blasting system according to claim 11 wherein the unique address is stored in the fresh detonator, a confirming signal is transmitted from the fresh detonator to the control means, and the control means then generates and transmits a signal on the status of the fresh detonator or

of its connection to the trunk line.

13. Apparatus for use in a blasting system to which a plurality of detonators are successively respectively connected, the apparatus including means for generating and transmitting to all of the detonators in the system at least one test signal, means for receiving at least one signal which is transmitted by a detonator, which has been freshly connected to the system, in response to the test signal and which relates to the quality of the connection of the detonator to the system, means for providing an indication of the said connection quality, and means for generating and transmitting to the freshly connected detonator an address which uniquely identifies the detonator.

14. Apparatus according to claim 13 wherein the means for providing an indication of the quality of the connection of the freshly connected detonator produces at least one of the following: a visual display; an audible signal.

15. Apparatus according to claim 13 or 14 wherein the said indication of the quality of the connection is transmitted to a location which is near the freshly connected detonator.

16. A method of installing a detonator in a detonating system substantially as hereinbefore described with reference to the accompanying drawings.

17. Apparatus for use with a detonator substantially as hereinbefore described with reference to the accompanying drawings.

DATED this 2nd day of MARCH 1994

McCALLUM RADEMEYER & FREIMOND

Patent agents for the applicant

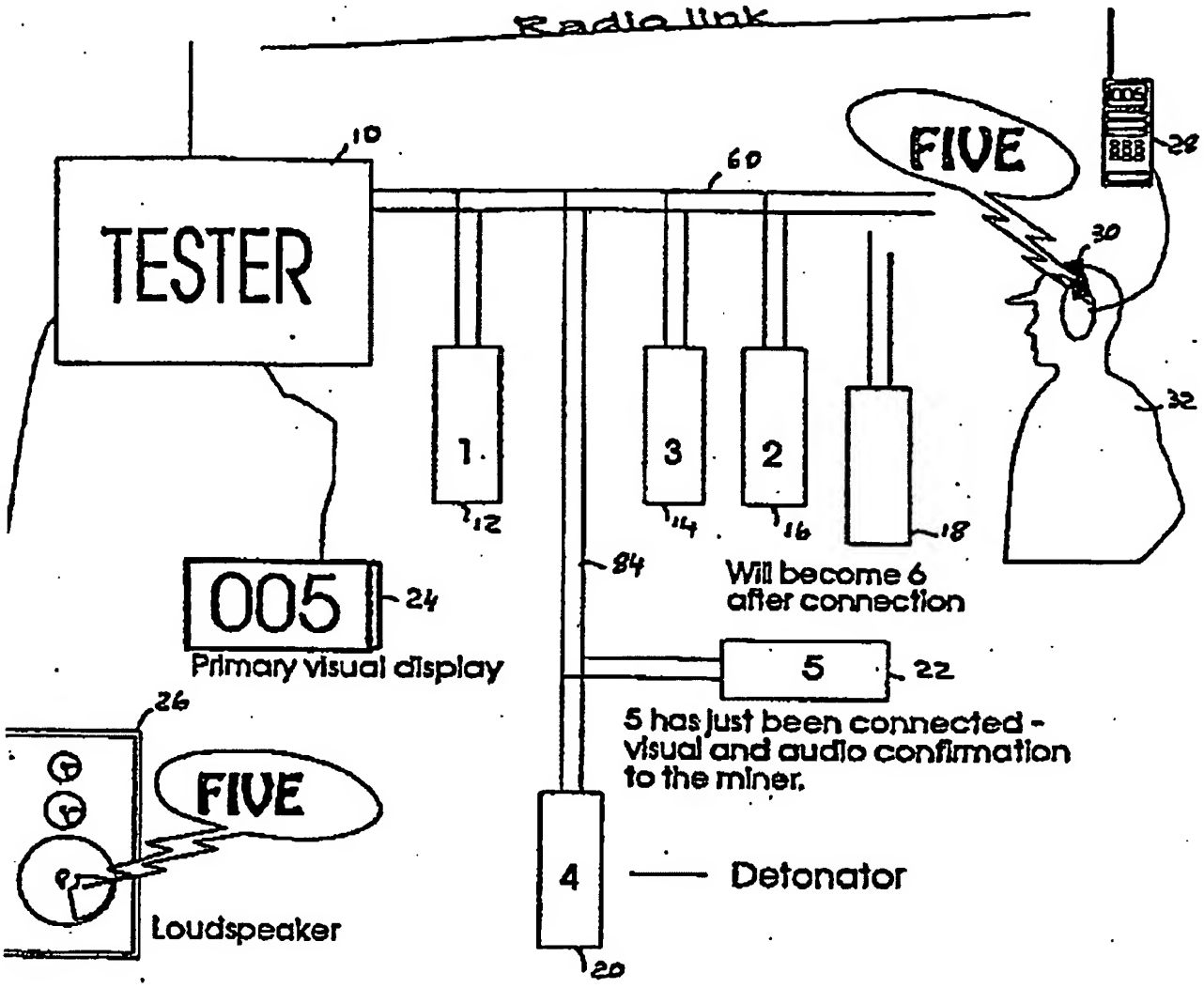

Fig 1

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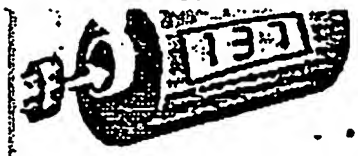

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PATENT AGENTS
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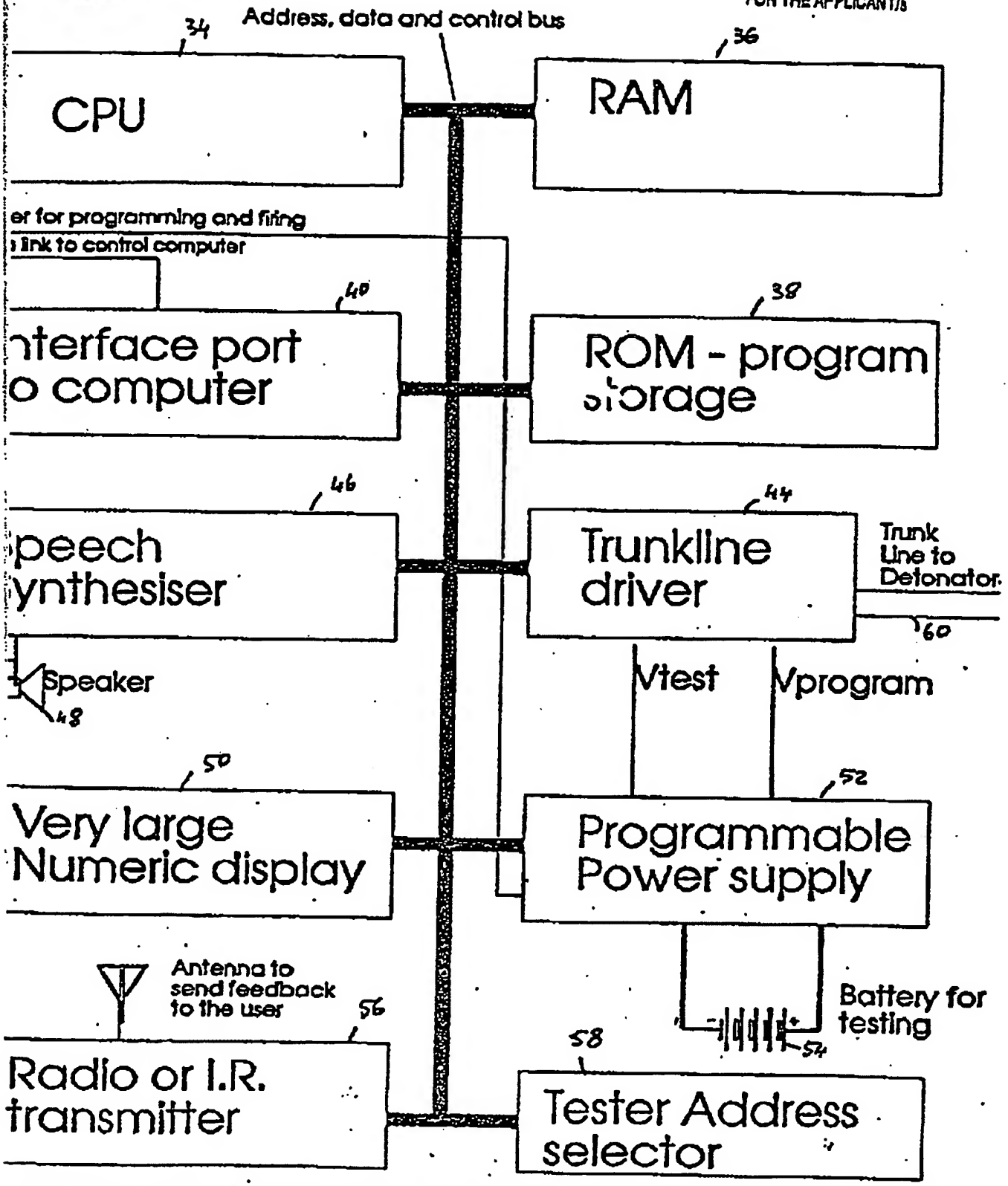

COMPLETE APPLICATION

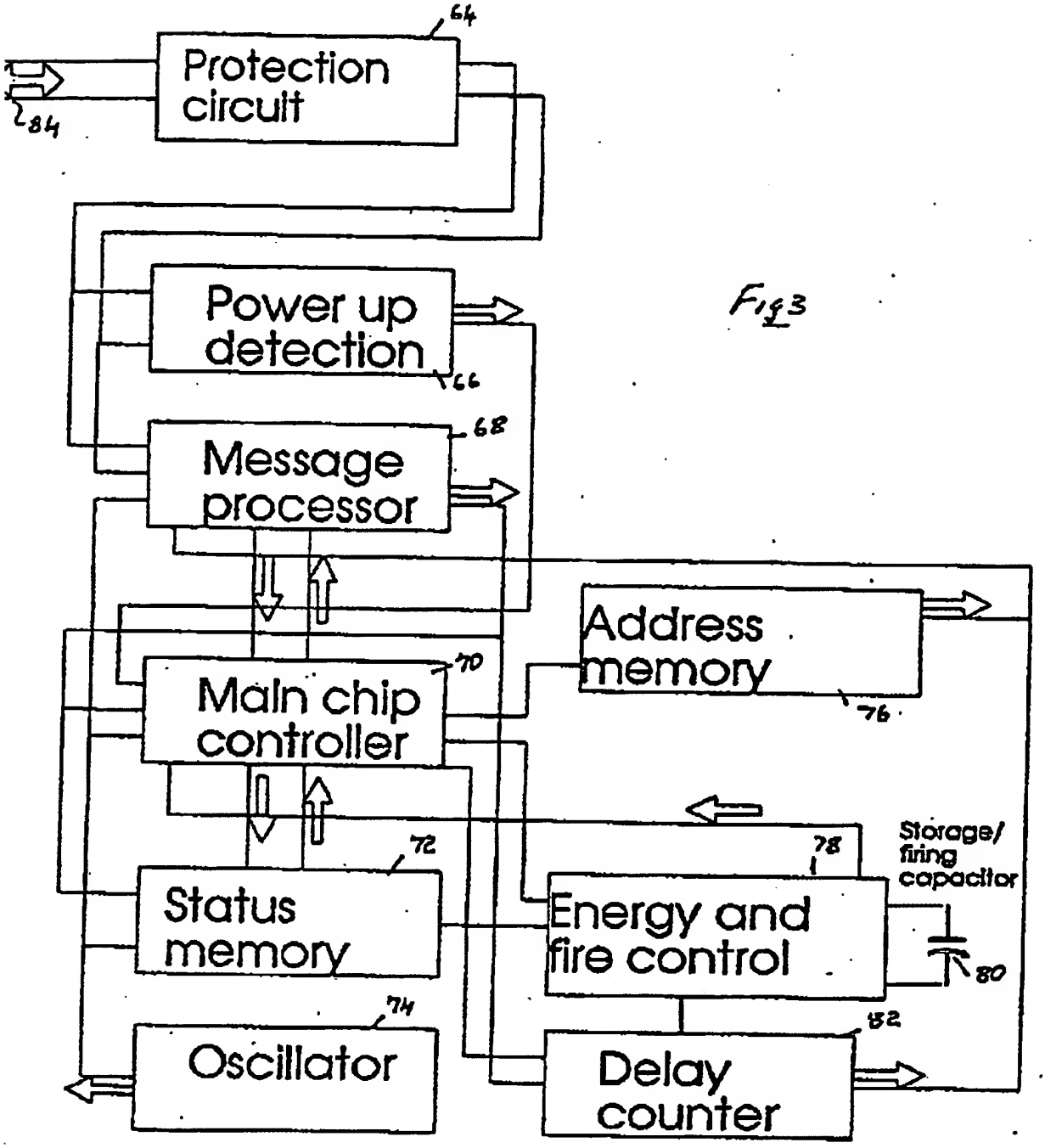

Fig 3

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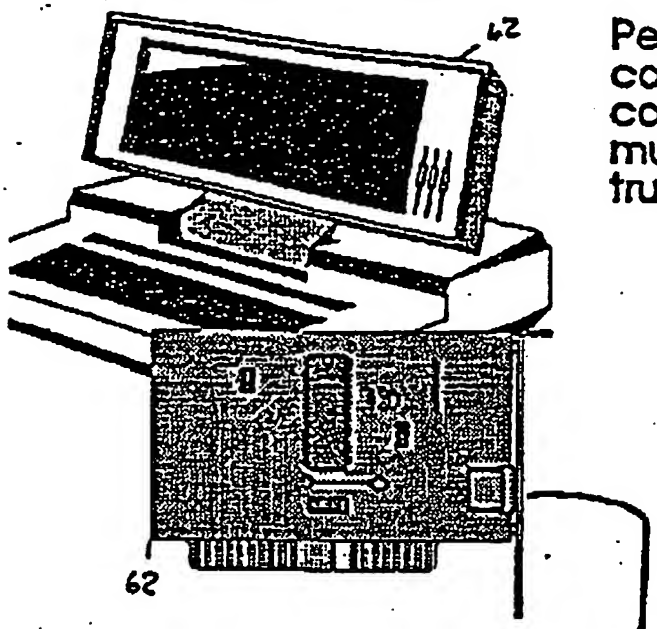
COMPLETE APPLICATION



Personal or dedicated computer used as to control a blast with multiple testers and trunk lines

Card plugs into computer for multi drop communications to several testers. The power to initiate the detonators is sent from this card.

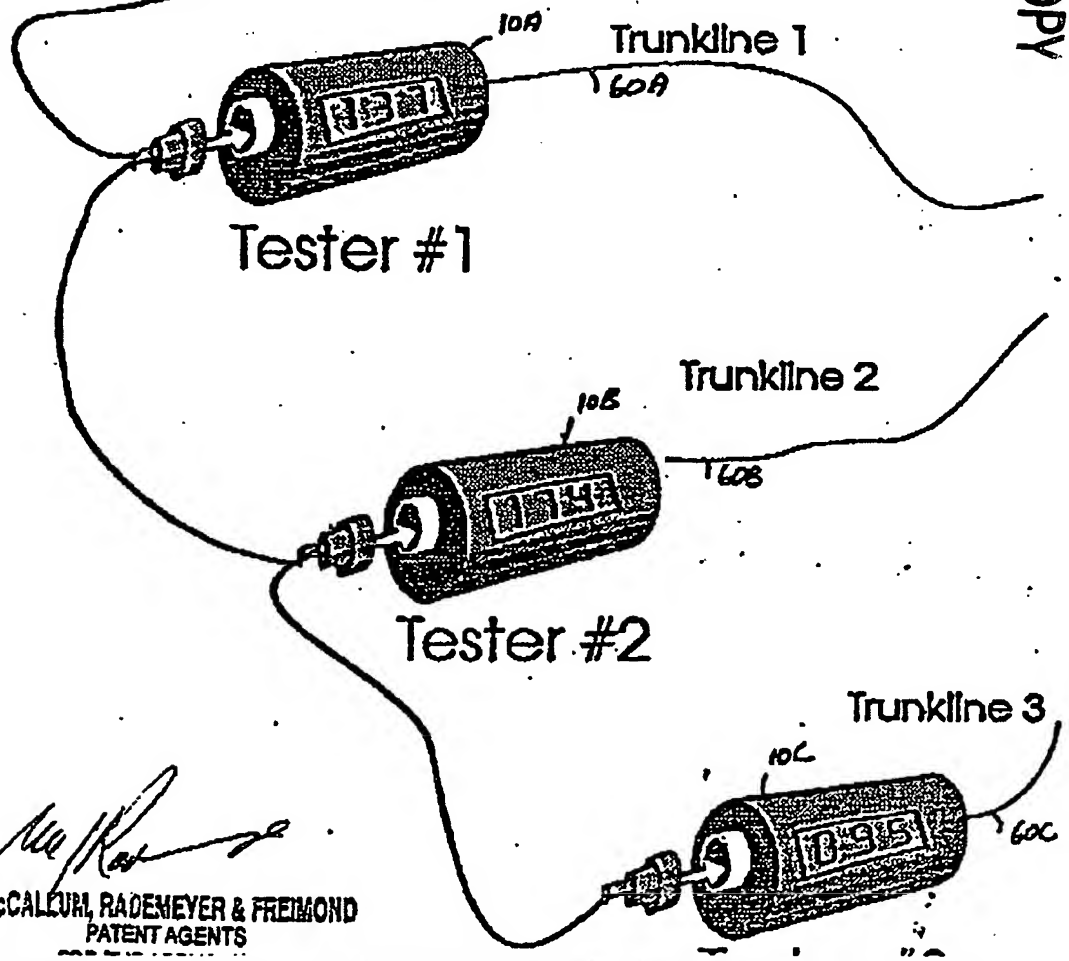


Fig 4

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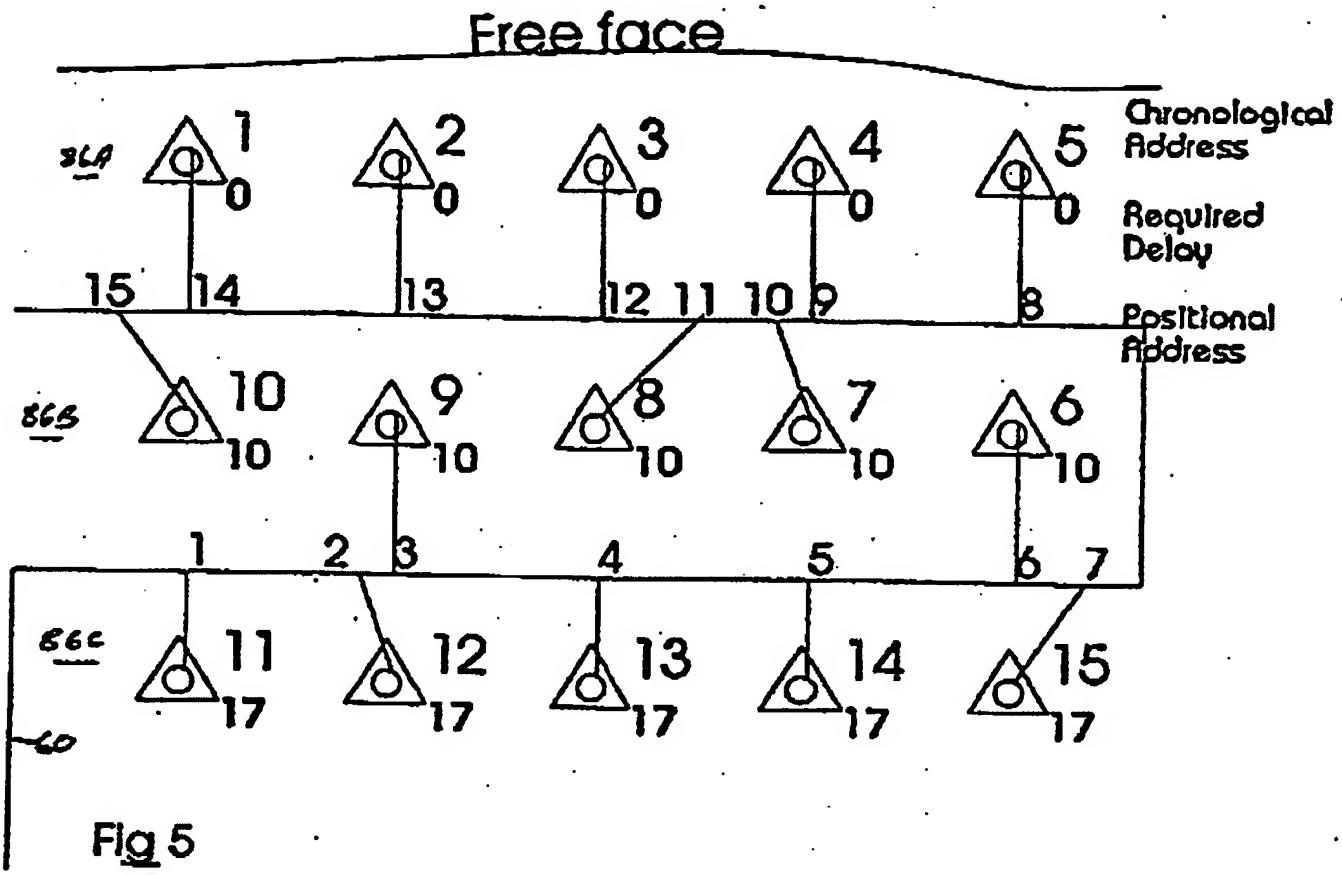

Fig 5

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